Quick change artists

Auto-darkening lenses switch from light to dark the moment an arc is struck. And this has important implications for the safety of welders, including constant protection from accidental arc flashes and a reduction in repetitive strain injuries of the neck.

By Dale B. Pfriem

Auto-darkening welding lenses were introduced in the late 1970s and there has been confusion about them ever since. Much of this confusion is due to the fact that today's auto-darkening lenses — also known as self-darkening or automatic lenses — bear little resemblance to their earlier counterparts. The first models, although highly touted, performed quite poorly when compared to today's models.

Since then, the technology has evolved rapidly. Today, auto-darkening technology is in its fifth generation. In addition, the organizations responsible for national safety standards are finally establishing guidelines that specifically address the performance and safety criteria of auto-darkening technology.

Photo: Courtesy of Hornell Speedglas Inc.

Automatic lenses allow welders to keep their helmets down all the time, providing constant protection.

Improved welder safety

Auto-darkening lenses are not merely a convenience for welders: they are an effective way to assure the full-time protection of a welder's eyes and face. According to a study by the U.S. Bureau of Labor Statistics in 1983, 67 per cent of welding injuries involved the eyes. Half of these injuries occurred when welding lenses were not worn. Why would anyone ever weld without eye protection in place?

There are a number of reasons. With traditional welding protective lenses, welders simply cannot see their work before an arc is struck. Seeing nothing but darkness, welders are nonetheless expected to be accurate within an eighth of an inch when placing the electrode for the crucial first arc. Conventional practice is for the welder to align the electrode with the helmet up and then to "nod" the helmet down before striking the arc. Unfortunately, this nodding causes an involuntary movement of the welder's hands, ruining the most careful electrode placement.

Frustrated welders sometimes take safety short-cuts, such as keeping their helmets up and then closing their eyes or looking away just before the initial arc is struck. Tack welders are particularly infamous for welding without safety headgear in place because of the nature of their task.(A tack weld is a very short weld used to hold two pieces of work together, usually before a long weld is made.)

Furthermore, studies indicate that welders are frequently "flashed" by other welders working nearby. With traditional lenses, welders expose themselves to nearby flashes whenever they are not welding and their protective helmet is not in place. Some production welding requires two or more welders to work on the same piece at the same time, increasing the likelihood of accidental flashings. In addition, walls, equipment, partitions and the workpiece itself can "bounce" ultraviolet radiation, causing harmful indirect arc exposure.

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Automatic lenses address these problems. The tint or shade of auto-darkening lenses quickly changes from semi-transparent to dark when a welding arc is struck, and then quickly changes back to semi-transparent when the welding stops *(see photos on page 10)*. This lets welders see clearly all the time, even when their helmets are down. This gives rise to at least six safety advantages when compared to traditional welding lenses:

1) Welders have increased protection from accidental arc flashes from nearby welders. This is particularly important where welders work opposite one another on the same piece of work.

2) Helmet nodding and the resulting neck strain — a worrisome ergonomic liability — are eliminated.

3) Welders can chip and clean a weld without changing safety headgear.

4) Welders can visually inspect a new weld without fear that the molten metal pool will suddenly contract and pop in their face.

5) Welders have a constant view of items around them, including potential hazards.

6) Welders are not tempted to cheat. That is, they are not tempted to keep their welding helmets up when doing very short welds, such as "tack" welds.

How automatic lenses work

Auto-darkening welding lenses have three major components: (1) an ultraviolet/infra-red (UV/IR) optical filter; (2) one or more liquid crystal light shutters; and (3) the associated electronics for detecting arc presence and controlling the shutters.

A crucial point for safety professionals to know and to teach to welders is that all current DIN (and future CSA) approved lenses have a failsafe UV/IR filter. That filter always provides protection from damaging ultraviolet and infra-red radiation. (The 1992 CSA standard will require lenses to provide the same UV/IR protection during their semi-transparent state as they do in their dark state.)

The UV/IR filter is completely independent of the electronic shutters. Put another way, the UV/IR filter is always in place, providing protection: it doesn't matter whether the viewing area is semi-transparent or dark, turned "on" or "off."

An automatic lens has photosensors that detect the light of a welding arc. This triggers the electronics that drive the lens's liquid crystal shutters to change their optical alignment into a shuttering (or darkening) formation. By changing from semi-transparent to dark, the lens eliminates the arc's bright, irritating, visible light. The welder can always clearly see the weld pool, at comfortable light levels — a very desirable practice for high-precision, high-quality welds.

Split-second exposure?

A welding arc creates a complex spectrum of light, parts of which include harmful ultraviolet and infra-red radiation that can cause "arc eye." A non-electronic, failsafe, optical filter built into approved auto-darkening lenses continually blocks those UV/IR parts of the spectrum. Fortunately, the UV/IR filter can also be designed to allow harmless, visible light from the green/yellow part of the spectrum to pass through. This allows welders to see at all times.

The first question virtually every welder and safety professional asks about auto-darkening lenses is: "Won't the eye be exposed to the harmful light of the arc for the split second it takes the lens to change?" The answer is an emphatic "no." The eye is never exposed — not even for a few milliseconds — to harmful UV/IR radiation because of the non-electronic UV/IR filter within approved automatic lenses.

The second question welders usually ask is: "What happens if the battery suddenly fails?" Different models react to sudden power or electronic failures in different ways; the developing standards will also address this issue. Most importantly, UV/IR protection is never affected in approved products.

Automatic lenses have been used widely in Western Europe for over 10 years. For example, full-time eye and face protection is so important for Sweden's safety professionals (because of their extensive metal fabrication and shipbuilding industries) that one in three Swedish welders now use automatic darkening lenses in their helmets. Automatic welding lenses are steadily work-

STANDARD IS COMING

Auto-darkening lenses, like their more traditional counterparts, should be submitted for approval to the Canadian Standards Association to see if they meet the requirements of CSA Standard Z94.3, *Industrial Eye and Face Protectors*. In the U.S., both types of lenses should meet the requirements for eye and face protection set by the American National Standards Institute in its standard ANSI Z87.1.

Currently, both the CSA and ANSI standards address critical safety concerns presented by conventional welding lenses. CSA is currently revising the eye and face protection standard for welding to include, for the first time, requirements unique to auto-darkening lens technology. In the U.S., the Industrial Safety Equipment Association (ISEA), in collaboration with ANSI, has initiated a similar effort.

To know what the new North American standards will be like, we can look to Europe, where auto-darkening technology was first perfected. Exhaustive studies were performed in Europe during the last decade on the possible health effects and glare attributes of millisecond exposures to visible light from automatic lenses. These studies were the basis of the first standard for automatic lenses: the 1987 West German standard — DIN 4647 Tiel 7.

The DIN standard, in turn, was the basis for the new European Community standard (CEN 379), now in final draft form. The CSA subcommittee responsible for drafting the standards for automatic welding lenses is closely reviewing the CEN standard and incorporating much of it into its own.

The CSA is addressing the more critical requirements for automatic lenses into the upcoming release of CSA Z94.3. The requirements will include switching times and maximum light transmission criteria (ultraviolet, visible and infra-red) for both light and dark states. Less critical performance issues are still under review and should be forthcoming by the end of 1992.

Many auto-darkening lenses sold in North America have the DIN 4647 Tiel 7 approval. So, until Canada's new standard is in place, you may want to contact the manufacturer to determine if a specific lens has DIN approval.

ing their way into North America's biggest companies, in industries such as automotive, aerospace, utilities, metal fabrication, pulp and paper and farm equipment manufacturing.

How fast is fast enough?

How quickly a lens switches from semi-transparent to dark is important — up to a point. Very slow shutters can allow irritating exposure to bright visible light. Slow shutter speeds were an irritating problem with early automatic lenses. Most of those models are no longer on the market.

Effective, safe switching times vary according to the specific light and dark states (shade levels) of any given lens. In general, the greater the difference between light and dark states, the faster the switching time must be. The German DIN 4647 Tiel 7 standard and the new, 1992 CSA standard for switching times are shown in Table 1 *(see chart on this page)*. For now, safety professionals can look for lenses with current DIN approval to assure safe and comfortable switching times.

Switching speed becomes irrelevant, however, if the light state is still too dark for a welder to see his or her work. Safety professionals must make sure the light state of a lens is right for the welder.

Application considerations

Automatic darkening lenses are simple to use. Typically, the welder just turns the unit on and dons the helmet. The light state is usually six to nine shades lighter than the dark.

Some models let users adjust their helmets to achieve the dark lens shade needed. Multiple-shade adjustment is convenient for welders who frequently change welding processes or amperages. Many, however, need only one dark shade level because they do the same type of welding all the time.

Some models have adjustment options for arc-detection modes and sensitivity levels. These adjustment options expand the application of automatic lenses to all types of arc welding, including low-amp TIG, inverter and other low-pulsation processes that could otherwise fool the lens's photosensors.

Top: Before the arc is struck.
Middle: After the arc is struck.

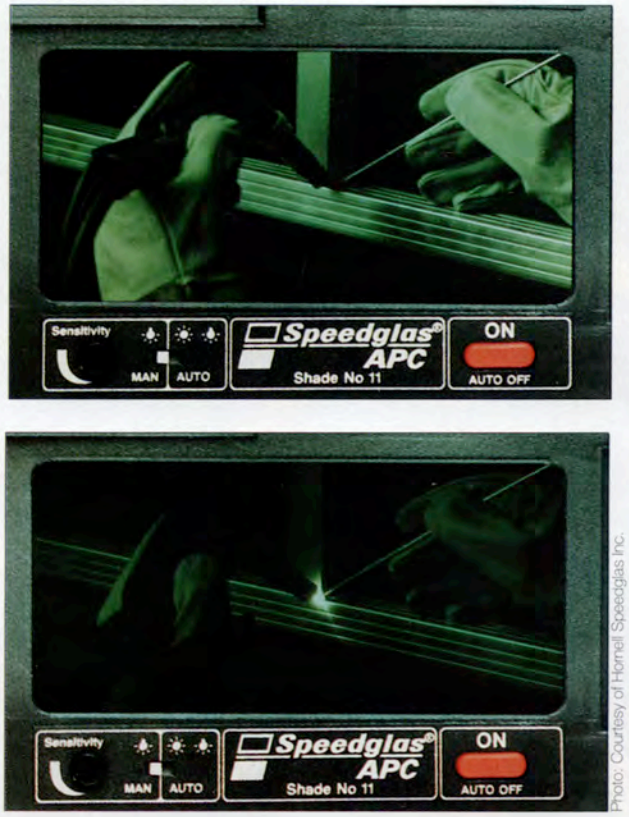

Photo: Courtesy of Hornell Speedglas Inc.

TABLE 1: SWITCHING TIMES

Dark shade	Light shade						
	1.7	2	2.5	3	4	5	6
	Switching time in ms (max)						
7	300	400	500	700	1000	N/R	N/R
8	100	150	200	300	500	1000	N/R
9	40	50	70	100	200	400	700
10	20	20	30	40	70	100	300
11	6	7	10	15	30	50	100
12	2	3	4	5	10	20	40
13	0.8	1	1.5	2	4	7	10

Depending on the environment the lens will be used in, some models can be fooled by variables such as bright sunlight. The lens may constantly flicker between light and dark states when the welder isn't welding. However, there are lenses available that work very well under any lighting conditions, both indoors and out.

Most models are battery-powered, with batteries typically lasting an average of 1000 hours. Some models come with "auto-off" to save on batteries: the lens turns itself off if it hasn't sensed a flash within a given number of minutes. Some models are solar-powered or solar-power-assisted by the welding arc.

Like traditional lenses, most automatic lenses have replaceable inner and outer protective plates. These should be cleaned and replaced as needed. Other than occasionally replacing a battery, no special care or maintenance is required for automatic lenses.

Lens performance

Real-world field testing by welders indicates four important performance criteria:

1) switching stability;
2) switching speed;
3) optical quality (clarity); and
4) ruggedness.

Switching stability (or trigger stability) means that a lens only switches when it is supposed to. A trigger-happy lens can unnecessarily switch to dark because of ambient (non-welding light), or it can prematurely switch to light, for example when the welder momentarily blocks the arc with his or her hand. Obviously, unstable switching is very irritating to welders. "Intelligent" lenses are available that respond only to the arc's presence.

Switching speed is discussed above. While speed is important, it is not the sole criteria for lens selection.

Optical quality or (or optical clarity) varies greatly among different models. Basically, the welder should never have to think about lens clarity. Poor lens clarity can include shadowing, fluttering, halo-effects around the edges of the lens and image persistence. Image persistence may occur, for example, during stick welding when a shower of sparks persists as an image in the lens, like tracers.

Ruggedness is important to welders. Some automatic helmets can be treated like any other welding helmet; others are fragile. Lenses recessed back into the helmet offer increased lens protection, as do inner and outer lens cover plates. A simple test of ruggedness is this: ask the lens salesperson to drop a lens installed in a helmet from at least table height — the higher, the better.

There are automatic lenses available that are fast-switching, are highly stable and "intelligent," offer excellent optical quality and are very durable. Extensive field-testing and word-of-mouth reporting will point you to those lenses. Don't just rely on the manufacturer's claims.

Welder education and acceptance

Safety professionals should educate welders about automatic lenses before having them switch from conventional lenses. Otherwise, welders may distrust the new lenses, erroneously believing they will expose their eyes to harmful radiation for the split second it takes the lens to change. A brief explanation about constant radiation protection from the non-electronic UV/IR filter, as well as a demonstration of the new lens, will usually satisfy their concerns.

Another consideration is the shade level. Even though all approved lenses will meet CSA standards, two Shade 11 lenses from two different manufacturers may vary slightly in their darkness. This holds true for both conventional and automatic lenses. If possible, when introducing automatic lenses, have your welders try the shade they're used to, as well as the shade above and below it. For example, a welder accustomed to Shade 11 should try an automatic lens in Shade 10, 11 and 12.

Lens viewing areas should also be considered. Many North American welders have become accustomed to conventional lenses with large viewing areas and they hesitate to switch to lenses with smaller viewing areas. Many large-view automatic lenses are now available, with viewing areas ranging from 44mm by 92mm to 55mm by 107mm.

Because of the increasing acceptance by welders of automatic lenses, manufacturers have begun to incorporate them into other products. In particular, automatic lenses are now available with powered air-purifying respirators and supplied-air respirators for welding. Welders gain the advantages of both constant eye and respiratory protection. Automatic lenses are particularly appropriate for cramped and awkward environments where respirators are frequently used. ■

The eye is never exposed to harmful UV/IR radiation because of the non-electronic filter within approved automatic lenses.