Derek Peach

A Decade of SON

Left: The Laker Skytrain hangars at Gatwick have recently been relighted. A hundred and sixty 400W SON lamps in Hi-Pak reflectors have been installed, half of them replacing 700W MBF lamps in the old hangar, where they reduced the loading from 60 to 32kW and raised the illuminance from 200 to 500 lux. The very long life of the SON lamps is likely to add a further cost benefit.

Mr. D. C. Peach is Product Development Manager for Light Sources at Thorn House.

High pressure sodium lamps have been commercially available now for at least ten years, so perhaps it is appropriate today to review the progress of this lamp which has made such an impact on the lighting market. The first SON lamps to be introduced were the 400W and 250W ratings and because of their high lumen packages and efficacy, they found immediate application for street lighting. As the dimensions of the SON were the same as those of existing mercury lamps of equivalent rating, a range of luminaires was already available, and by substituting the correct control-gear, SON was able to be offered to a wider market than would otherwise have been possible. Floodlighting was an obvious extension; again suitable lanterns were available, and the golden white colour of the light from the SON lamp has proved very acceptable for brick and stonework.

Bringing SON indoors

Because it is generally accepted that high colour temperatures are most acceptable at higher lighting levels, such as obtain in natural daylight, and that the lower colour temperatures are more popular at lower illuminances, such as may be found in domestic lighting, it can be expected that SON, with a colour similar in some respects to a slightly under-run filament lamp would be most acceptable in the latter.

Commercial interiors

The lamp has already proved its worth in industry, and the introduction of lower powered lamps may well provide the impetus for it to penetrate commercial interiors. Obviously its use in such places needs to be treated with care, but there is already evidence that its use in these situations is growing.

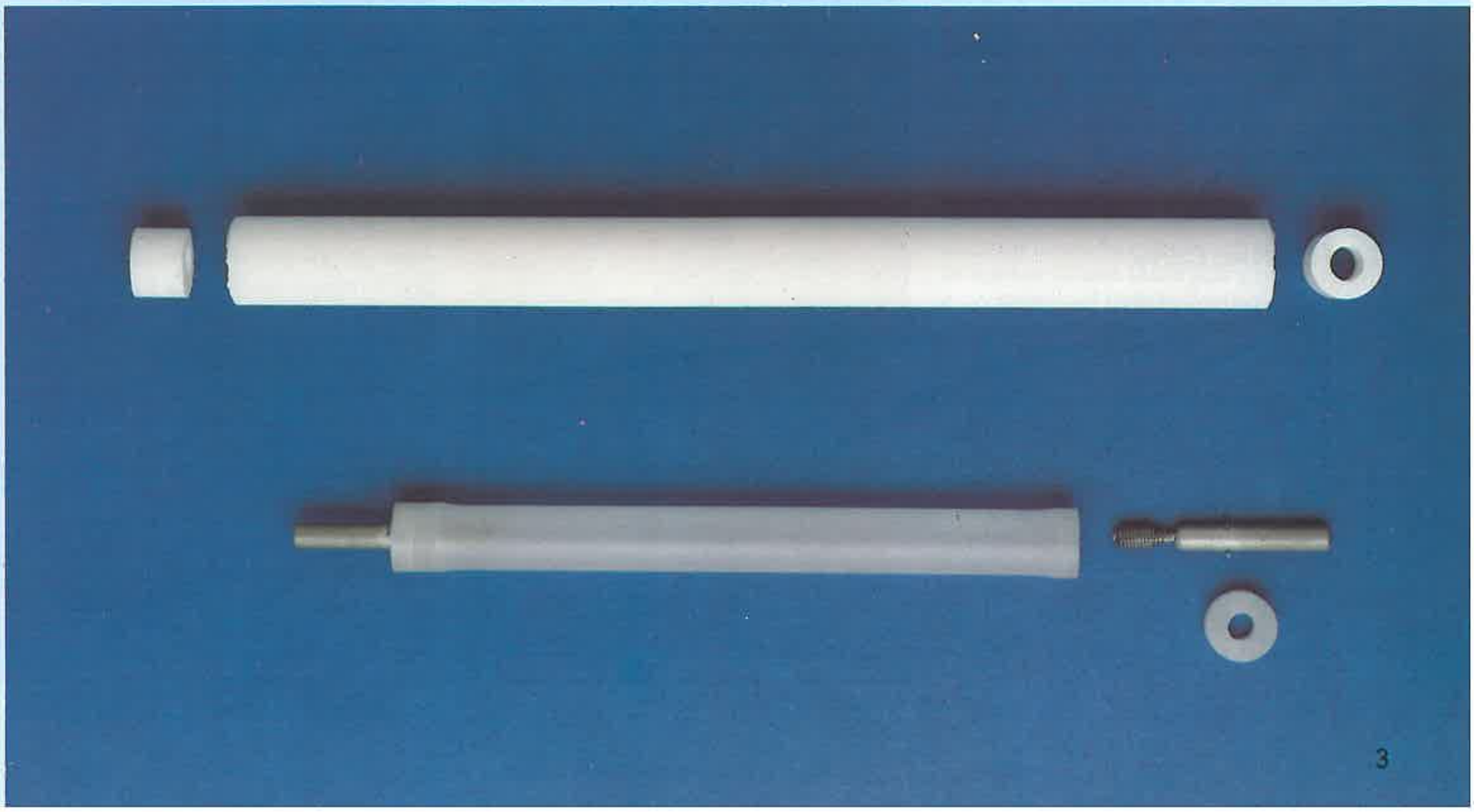
Because of the pleasant effect on stonework mentioned above, it is beginning to appear in churches; SON lamps are used to augment the daylight under the dome of St. Paul's and in the Anglican Cathedral in Liverpool, and it is not out of place in such buildings. Another, rather surprising area in which it is gaining ground is the lighting of swimming baths, where it makes pale bodies look more healthy.

SON in industry

The initial industrial applications were almost exclusively confined to high-bay lighting. The long lamp life and good lumen maintenance has reduced operating costs considerably and this application is still growing, but the use of SON lamps has now been extended to situations with lower mounting heights and the introduction of the Thorn Lo-Pak range of fittings, as well as that of the 70W and 150W lamp ratings, has encouraged this development.

The 70W rating, originally intended for street lighting, has also

Components of the arc tube of a SON lamp. The alumina arc tube and plug shown below are in their 'green', unheated state. After the plugs have been inserted, the tube is heated to a temperature of about 1800°C in a furnace, so that the individual grains of aluminium oxide coalesce to form the much smaller but infinitely stronger arc tube seen below. The plugs are fused into the tube forming a 'monolithic' construction. The electrodes are then inserted, each within a frit or washer that is heated in vacuo to form a solid gas-tight seal.



enabled commercial luminaires to be produced. These are suitable for use in shops, foyers, staircases, lift halls and similar locations. The recent announcement of the 70W reflector lamp (another Thorn first) is likely to turn attention to the possibility of using it in downlighters and swivel-mounted display fittings. In the latter case, one can see the possibility of providing economical lighting in a shop window. SON lighting is used on railway stations, airports and sports halls and indeed its use is spreading to most areas where there are long operating periods and high labour costs. There is no doubt that as the range of lamps widens, so will the market.

Technical difficulties overcome

The fact that increasing the pressure of sodium in the discharge would lead to an improvement in colour was known in the laboratory for many years, but the technical problems of producing a gas-tight envelope which would resist the attack of sodium at high pressure and temperature and withstand temperature changes over a range of from 0° to 1300°C were very difficult to solve. The material used for the arc tube is polycrystalline aluminium oxide — alumina — and as it is not possible to work this material in the same way as the more conventional glass or quartz, entirely new methods of sealing the arc tube had to be devised.

Sealing the arc tube

At first a metal cap was used at the ends of the arc tube to produce this seal and to support the electrodes, but because of the inherent difficulties in this form of construction, leaks in the seal area

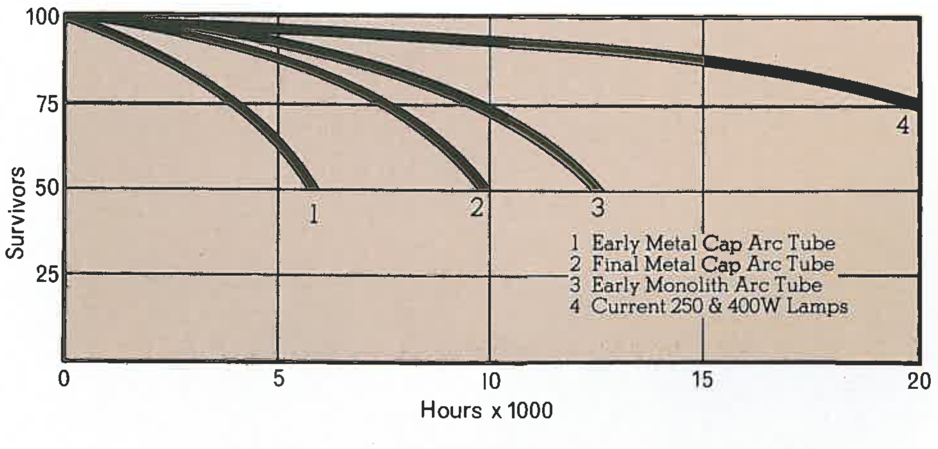
The British Oxygen Company's factory at Ramsgate, Kent is lighted by 204, 250W SON lamps in Hi-Pak fittings, and was commisioned in August 1977. Only four lamps have failed since installation, in nearly 18,000 hours use.

were the most common form of failure in early commercial lamps and average life was only 6,000 to 8,000 hours. The introduction of the monolith construction by Thorn in 1975 effected a dramatic improvement in reliability.

Monolith construction

In order to seal the electrode assemblies into the ends of the alumina arc tube, a hollow plug of the same material is inserted at each end of the tube. This is then fired at 1800°C in a hydrogen furnace to fuse the plugs and tube into a homogeneous whole, hence 'monolith'. The electrode mount is then inserted through a hole in the plug and sealed with a 'washer' of ceramic forming a large seal area of great strength. This construction

SON Survival Curve



effectively eliminates the leak problem of the earlier metal capped lamps and the reduction in early failures due to leaks has increased the average life of the lamps considerably.

Determining lamp life

The life of discharge lamps is best shown on mortality curves which indicate the number of survivors to be expected from a representative batch of lamps throughout a determined period of time. Generally failures are likely to occur from two main causes.; First, the intrinsic 'life' of the product, that is to say the time that elapses before the electron-emitting material coating the electrodes is exhausted, or the electrode itself disintegrates and second, random failures due to manufacturing tolerances, limiting technology, adverse environmental conditions and so on.

Effect of random failures

In the first few years after the introduction of a new product, these random failures are usually predominant and produce a curve such as here shown as 1 in the graph. As the various causes of early failure are identified and cured, the curve begins to improve until the majority of the reasons for early failure have been eliminated (curves 2 and 3). For an established lamp the curve should stay close to the 100% survival line for a fair proportion of the lamp's life before failures begin to increase. This situation (curve 4) has now been achieved on the established SON ratings and the 250W and 400W lamps, for example, will now reach 10,000 hours with a negligible percentage of failures. Each new rating introduced is bound to have its own peculiar set of problems and although the experience gained on other ratings helps the lamp engineer to achieve reliability sooner than in a pioneer lamp type, over the first year or two after the introduction of a new lamp rating its reliability will never be so good as that of an established one.

Advantages of an external ignitor

The excellent reliability achieved by Thorn SON lamps has been helped by the Company's policy of operating them with an external ignitor, designed and manufactured by Thorn to suit the lamp. Only with an electronic ignitor can a reliable starting pulse be produced, as it can be tailored to meet the requirements of the individual lamp, and at the same time comply with current and imminent international standards. Lamp reliability is only as good as the weakest link in the chain and eliminating all unnecessary components within the bulb reduces the risk of failure. Adding the many other components needed to produce a lamp with an internal starter inevitably leads to a loss of reliability, offsetting any initial savings in control gear.

Methods of life-testing SON lamps

In order to obtain information on the performance of SON lamps, samples are taken regularly from production and life tested on internal racks or on outdoor streetlighting columns. However, although this method gives the fastest results as lamps can be operated for 8,000 hours a year, relatively few lamps can be tested in this way and more representative information can be obtained by field testing larger quantities of lamps. From the results of many hundreds of lamps operated under normal streetlighting and industrial lighting conditions, mortality curves more representative of field conditiong can be constructed.

Such information was used to prepare the graph opposite.

Information from users

In addition to this information, SON lamps have now been in use in the market for long enough for users to appreciate their reliability and the installations shown in the table below illustrate this point, it must be appreciated that enquiries of this nature are bound to give less definite results than formal field testing.

The users' comments are remarkably favourable, especially in view of the fact that at least two installations used the 'first off' lamps. It seems likely that similar results will be obtained from installations of SON lamps in 'Lo-Pak' fittings, but these installations are too recent to be used in this survey, which can only include installations that have been in use for some years.

Lumen maintenance throughout life

A very important attribute of the high-pressure sodium lamp is its remarkably good lumen maintenance throughout life. The light-output of all lamps including fluorescent tubes diminishes steadily throughout life, so that even if a lamp continues to operate electrically for an extended period, it may cease to be an economical light source before it actually fails. The light output of Thorn SON lamps, however, is maintained extremely well throughout life, reducing by less than 1% per 1,000 hours after the 2,000 hour figure. This means that the excellent life performance is fully useable, the lamp giving adequate light output to the end. In the case of the Tecalamit Belliver installation shown in Table 1, for example, lightmeter readings showed a negligible diminution of illuminance after more than 10,000 hours life.

Research and development

Thorn has pioneered the introduction of smaller ratings of lamps, and here the facilities of the research laboratories at Leicester have been invaluable. Extremely elegant and effective methods of evaluating the optimum characteristics of lamps of different power ratings and arc pressures have been developed, as for example the indium bath method described by Dr. Wharmby in Lighting Journal No. 17 and these methods of investigation were used when the 150W, the 70W and most recently the 70W reflector ratings were developed and introduced. Development is continuing with the aim of producing lamps with even better colour-rendering properties and also in the direction of still lower wattage ratings.

Conclusion

In the decade since its introduction, the high-pressure sodium lamp has made astonishing progress from a laboratory novelty to a commercial lamp offering excellent value for money. Much of this is due to work in the Thorn laboratories. It does not seem unreasonable to predict that it may well prove to be the major discharge lamp of the future. It has the advantages of compactness and robustness and its long, reliable life, good lumen maintenance and steadily improving efficacy and colour-rendering properties make it likely to be seen in the future in situations which are at present the domain of the filament lamp and fluorescent tube.

User	Number and type of lamps and fittings	When installed	Approx. annual hours use	Users comments on Replacements
B.S.C.* Thryburgh bar mill	890 x SON.TD in SONLINE projectors	Nov. 1974	8,000	"First bulk change after 16,000-18,000 hrs very few failures at 16,000 hrs."
British Oxygen Co. Ramsgate	204 x 250W SON in high-bay fittings	Aug. 1977	6,000	"Four lamps have failed since installation; Installation very satisfactory in use"
C.E.G.B. Skelton Grange Leeds	40 x 400W SON in high-bay fittings	March 1977	8,000	"About half a dozen in two years"
Corporation of the City of London	350 x 150W SON in Alpha 8 Lanterns	Early 1978	4,000	Have now operated over 8,000 hours with no failures
Tecalamit Belliver, Plymouth	249 x 400W SON in high-bay fittings	July 1977	6,500	"12 failures in first two years. No measurable fall-off in illuminance"
Dunlop and Rankin Leeds	43 x 400W SON in high-bay fittings	March 1974	2,500	"In third year of installation 9 lamps had been replaced Completely relamped in November 1979"
J. Wilder, Engineers Wallingford	38 x 400 and 250W SON in high-bay fittings	1976-7	3,500	"Beginning to change a few lamps in January 1980"
Amersham** District Council	30 x 150W SON Street Lighting	1977	4,000	"Original lamps averaged 9,000 hours"

*The first large installation of SON.TD lamps

**The first field trial of pre-production 150W SON lamps.