Why Preheat?

By F. M. Burdekin*

[This short article is reprinted from "Australian Welding Journal— Autumn 1982" with the permission of the Australian Welding Institute and is one of a series of articles in which Professor F M. Burdekin of the Department of Civil and Structural Engineering, The University of Manchester Institute of Science & Technology summarises some fundamental aspects of metal cutting and joining. Based on previous experience, he gives tips to promote good practice and successful fabrication or construction.]

The vast majority of welding of structural steels is carried out without any need for, or consideration of, preheat. With high yield or low alloy steels, and with thick sections, precautions may be necessary to avoid heat affected zone (HAZ) cracking.

With the publication of BS 5135 : 1974, clear guidance became available in its Appendix E regarding the combination of factors which contribute to risks of HAZ cracking in carbon manganese steels. These are as follows :

(a) Chemical analysis of the steel, represented by the carbon equivalent (CE) formula :

$$CE = C + \frac{Mn}{6} + \frac{Cr+No+V}{5} + \frac{Ni+Cu}{15}$$

(b) Combined thickness at the joint to be welded, being the sum of the thicknesses (in millimetres) meeting at the joint.

(c) Heat input from each individual weld run, represented by the electrical energy input to the arc. For a given electrode type, heat input is roughly proportional to the size of weld run.

$$\text{Heat input} = \frac{\text{Arc volts} \times \text{Current}}{\text{Travel speed (mm/sec)} \times 1000} \text{ kJ/mm}$$

(d) Hydrogen potential level of electrode coating, to give estimate of hydrogen level in weld metal, given in BS 5135 as :

A>15 ml/100 gm
B 10-15 ml/100 gm
C 5-10 ml/100 gm
D O-5 ml/100 gm

(e) Preheat temperature.

BS 5135 Appendix E gives a series of tables and charts which enable one to calculate the preheat temperature to avoid HAZ cracking provided that the first four factors a-d above are known. Many welding engineers are used to using BS 5135 Appendix E to tell them whether preheat is necessary for particular joints in a structure to be built. The specification actually intends to give preheat figures to be tried and confirmed in procedure trials, because of additional effects of fit-up, restraint, etc., but is widely used to determine detailed welding procedures and preheat for actual fabrication.

Preheating is an expensive occupation, however, and if satisfactory alternative welding procedures can be derived without the need for preheat, there will often be a considerable financial saving. This is particularly

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the case in structural work where long lengths of welding may be involved, or there may be many similar repetitive joints.

There are three main ways in which the need for preheat can be reduced, and sometimes eliminated. All require some additional care and supervision and should be undertaken only provided that the fabricator is willing and able to provide the extra supervision. The consequences of attempting to use these methods, and failing because of lack of care and supervision will be extensive HAZ cracking, with the cost of repairs far greater than the potential savings from using procedures avoiding preheat. With these preautionary warnings here then are this month's Tips the past;

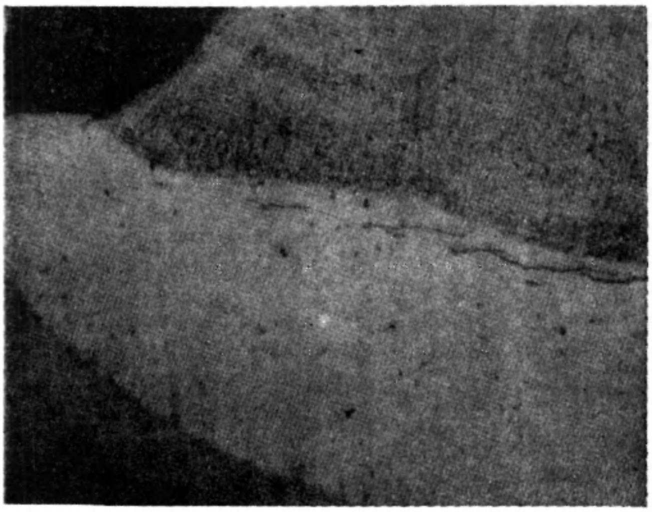
1. Wherever possible check the actual ladle chemical analysis of the plates or parts to be welded and calculate the carbon equivalent. Add about 0.05% to the carbon equivalent to allow for residual elements and variations from the ladle analysis. The resultant carbon equivalent will often (but not always) be less than the figures used in the summary tables for different grades of steel in BS 5135 (Tables 2-5). The use of the graphs in BS 5135 (Fig. 5a-n) will then lead to lower preheats than the summary tables.

1. Whenever possible use higher heat inputs from welding rather than preheat, to achieve the same effect. There are several ways in which this can be done :

   (i) Use a larger weld run size than the minimum specified if practicable, provided that the designer agrees, and that distortion is not a problem.

   (ii) Use multiple electrodes/welders to supply heat to the joint at the same time. For example, two welders working either side of a joint will double the heat input, and two welders following each other very closely will give a total heat input nearly equal to the sum of the individual inputs. With these techniques it is often possible to weld thick sections of Grade 50 steel without preheat, but the welders have to be trained, supervised (and paid extra ?). Be careful that the extra heat input does not lead to undercut in thin plates.

   (iii) For small repetitive joints, where access of more than one welder is impracticable, the same effect can be achieved by the welder making the first run (say one electrode run out length) and then immediately deslagging and placing the second run over the first.



Heat affected zone hydrogen cracking—a common consequence of incorrect preheating practice.

3. Reduce the hydrogen potential level of the electrodes by using basic coated low hydrogen electrodes, fully dried by baking at 400-450°C for 1-2 hours, followed by storing at 150°C until use. This should give hydrogen potential scale D of BS 5135. Any electrodes taken from storage and not used within about four hours must be put through the baking cycle again. This procedure requires very careful and rigid implementation of house-keeping procedures, and is recommended only for shop welding with strict control of issue and use of electrodes.