APPENDIX 1:- EXAMPLES OF THE OUTPUT FROM THE *k-□* SPREADSHEET PROGRAM

A spreadsheet program was developed based on the *k*-□ model for multi-pass overlays described in chapter 6. The original spreadsheet was developed solely by the author and applied to develop welding conditions for overlays trialed in the alumina industry (see Arnold *et al.*, 1998). The spreadsheet was subsequently refined and expanded with the assistance of Dr. B. Bednarz of CSIRO Manufacturing Science and Technology. Full details are presented in Francis *et al.* (1998).

Examples of the output from the final version of the *k*-□ spreadsheet program are included at the end of the appendix. A worksheet for 4mm high single-layer weld overlays is shown. The user may enter data in areas that are shaded yellow. There are two yellow boxes in the top-left hand corner of the worksheet where the user can enter the substrate and consumable composition. Also within the purple region there is a yellow box where information relating to the deposition rate can be entered.

There are three main user areas in the worksheet. The first, User Area “A”, shows output for a matrix of different welding conditions. In this area the user may change only the voltage. It was intended that this area would give the user an appreciation of the effects of different welding variables. For example, given a consumable with an all-weld-metal composition of 25wt.% Cr and 5wt.% C (and deposition properties as given on the worksheet), deposited on to a mild steel substrate, a low-dilution welding condition is the following;

28V, 350A, 40mm work distance and 900mm/min. The calculated steady-state dilution is 24% and the corresponding carbon and chromium concentrations are 3.8% and 19.0% respectively. The overlay would be hypereutectic. The predicted ripple is 0.7mm using an approximation developed prior to the one presented in this thesis. The earlier version is also given in Francis *et al.* (1998).

The second area, User Area "B", allows the user to enter any combination of voltage, current, work distance and travel speed. In this area the spreadsheet will automatically calculate the step-over that is required to achieve a 4mm high overlay. Predictions of various parameters, including the steady-state overlay dilution, are then given. In User Area "B", four sets of welding conditions can be compared simultaneously for a specified height of 4mm.

Finally, User Area "C" allows the user to enter the voltage, current, work distance, travel speed and step-over. The spreadsheet will then estimate the steady-state overlay height that will result from the welding conditions that were entered (*i.e.* the height is no longer restricted to 4mm). Predictions of various parameters, such as the steady-state overlay dilution, are then given. In User Area "C" four different sets of welding parameters can also be compared simultaneously.

It can be seen that the worksheet does not give predictions for all of the entered welding conditions. The predicted steady-state dilution *etc.* will only be given if the welding condition is deemed to be viable, and there is a column in the worksheet that states whether the welding condition is expected to be viable or not. The viability of a welding condition is based on the estimated overlap. Bead overlaps between 40 and 60% are generally recommended (Gorman, 1997). Overlaps higher than 60% are likely to result in a low average penetration and, if the penetration is inconsistent, lack of fusion may occur. Conversely, if the estimated overlap is below 40%, the peak-to-valley ripple may be large. In the example shown, an overlay is deemed to be viable if the estimated overlap is between 40 and 60%. However, the user may alter these limits by adjusting the viability parameter at the top of User Area "A". The limits on bead overlap are set to "50 ± viability parameter". The viability parameter is set to 10% in this example so the limits on bead overlap are 50 ± 10%, i.e. 40 and 60%.

The columns in red predict the wire feed rate that corresponds to the entered welding condition. The estimated steady-state height of the overlay is based on this estimated wire feed rate. This column is highlighted to emphasize that it is possible to ensure that the correct overlay height is achieved by controlling the wire feed rate directly.

The worksheet shown is for 4mm high single-layer overlays. The complete *k-□* spreadsheet program also has worksheets for 2mm, 3mm, 5mm and 6mm high single-layer overlays. In addition, two worksheets are included for double layers. One applies to a 2mm high overlay being deposited on another 2mm high overlay. The other applies to a 3mm high overlay being deposited on another 3mm high overlay.