into. If there are safety requirements placed on the equipment, most of the burden falls on the power supply. These safety specifications affect the way the transformer is assembled and the area needed by the windings. Inevitably, the effect is to increase the size of the transformer since insulating tape must be used during the winding of the transformer. So the designer should take this added volume of the tape insulation into account. The first step is to choose the average current density (I_D) the wires must carry. Typical ranges fall between the values of 400 and 1000 circular mils per ampere. This influences how much heating will occur in the windings. The worst-case average current in the primary winding will be

$$I_{in}(\mathrm{av}) = \frac{P_{out}/E_{ff}(\mathrm{est})}{V_{in}(\mathrm{min})} \tag{6.11}$$

Referring to the wire data in Table 6.1, the cross-sectional area of the wire used in the primary is determined. Next the designer uses an equation developed as a guide by the core manufacturers:

$$W_a A_c = \frac{0.68 \cdot P_{out} \cdot I_D \cdot 10^3}{B_{max} \cdot f} \qquad (B_{max} \cong \tfrac{1}{2} B_{sat}) \tag{6.12}$$

This yields a number that is valid for a basic two-winding transformer. If multiple output windings are required, then increase this number by 30 to 40 percent. If approval from Underwriters Laboratory (UL) or the German Institute of Electrical Engineers (VDE) is needed for the power supply, then add another 20 percent to the result. At this point, a core size can be selected by finding a core that has a $W_a A_c$ equal to or larger than the $W_a A_c$ calculated above.

Once the particular size core has been selected, the windings themselves can be determined. The turns needed by the primary can be found by

$$N_{pri} = \frac{V_{in}(\mathrm{nom})10^8}{4f \cdot B_{max} A_c} \tag{6.13}$$

This number now serves as the basis for all the other windings on the transformer.

In determining the number of turns required by the highest power secondary, a few items must now be considered. The forward voltage drop of the rectifiers cannot be ignored, and the maximum allowed pulsewidth of the control loop should be included. This can be done by applying the following equation:

$$N_{sec} \geq \frac{1.1(V_{out} + V_f)}{N_{pri}(V_{in}(\mathrm{min}) - V_{sat})D_{max}} \tag{6.14}$$