APPENDIX 2
SOME PROPRIETARY LOW-NO_X, BURNERS

Manufacturers of boilers and burners have worked the various NO_x reduction technologies into new equipment designs that are proving to be very successful in reducing emissions. Some have developed low-NO_x burners that can be retrofitted to existing boilers and heaters; others have designed complete systems, integrating burner and furnace design for best effect. The following describes only a few.

The Pyrocore® burner, developed by Alzeta Corporation, combines the NO_x-reduction techniques of accelerated combustion and flame chilling. Natural gas and air are premixed, then fed through a large cylinder made of porous ceramic fibre or porous metal, and ignited on the outside surface. The flame is large in area but only a few centimetres long, and relatively cool; between 925 and 1000 °C, so both the low temperature and short residence time inhibit the formation of thermal NO_x. A single burner system can be fitted into a conventional boiler, as shown in Figure App 2-1. For large outputs a specially designed boiler is available; it has two, four or six watercooled furnace tunnels to maximize heat transfer and ensure that burner segments don't overheat. These burners generally produce less than 30 ppm NO_x (corrected to 3 % O_2) when fired with natural gas.

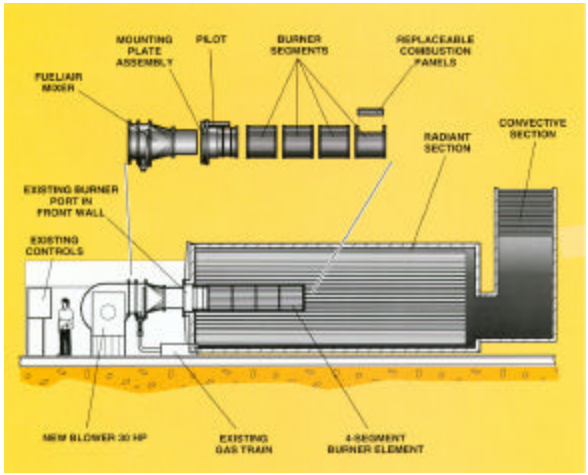

Figure App 2-1 Ceramic Low-NO_x Burner (Courtesy Alzeta Corporation)

A system, which combines flame chilling, air staging, and internal flue gas recirculation (FGR), is the Donlee Turbofire® burner/boiler, shown in Figure App 2-2. It employs cyclonic combustion; a fuel-rich mixture is injected tangentially at high velocity into a watercooled combustion chamber, which results in rapid flame chilling. The swirling action of the tangential flame creates a zone of low pressure in the centre of the furnace, which pulls in flue gas from the furnace exit, thus providing internal flue gas recirculation and further reducing flame temperature. Further downstream, secondary air is added to complete the combustion process. The

manufacturer claims that NO_x emissions of less than 30 ppm can be readily achieved when firing natural gas, and that they can be further reduced by injecting steam into the flame zone.

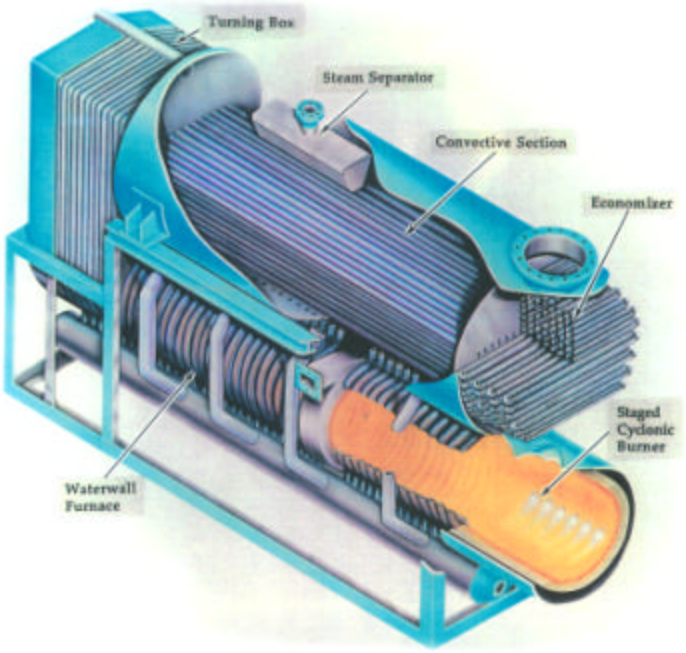

Figure App 2-2 Turbofire® burner/boiler (Courtesy Donlee Corporation)

Low-NO_x burners are the most common means for reducing NO_x emissions from industrial boilers. There are more than a dozen well known suppliers offering more than two dozen designs. Most of them employ some combination of air staging and fuel staging and FGR. The FGR is usually external, that is, drawn from the boiler exit through a duct back to the windbox, but sometimes it is internal, recirculated within the furnace by burner aerodynamics. Figures App 2-3, App 2-4 and App 2-5 show only a few examples of what are available.

Figure App 2-3 Low-NO_x Oil/Gas Burner (Courtesy of Peabody Engineering Corp.)

Most suppliers of low-NO_x burners would be willing to guarantee compliance with the CCME emissions guidelines for operation with natural gas and distillate oil, and the record of achievement with these fuels is fairly good, at least for smaller boilers. There has not been much success in reducing NO_x emissions from residual oil, and if burner suppliers offer an emissions guarantee for this class of fuels at all, it is certain to include a limit on fuel nitrogen content.

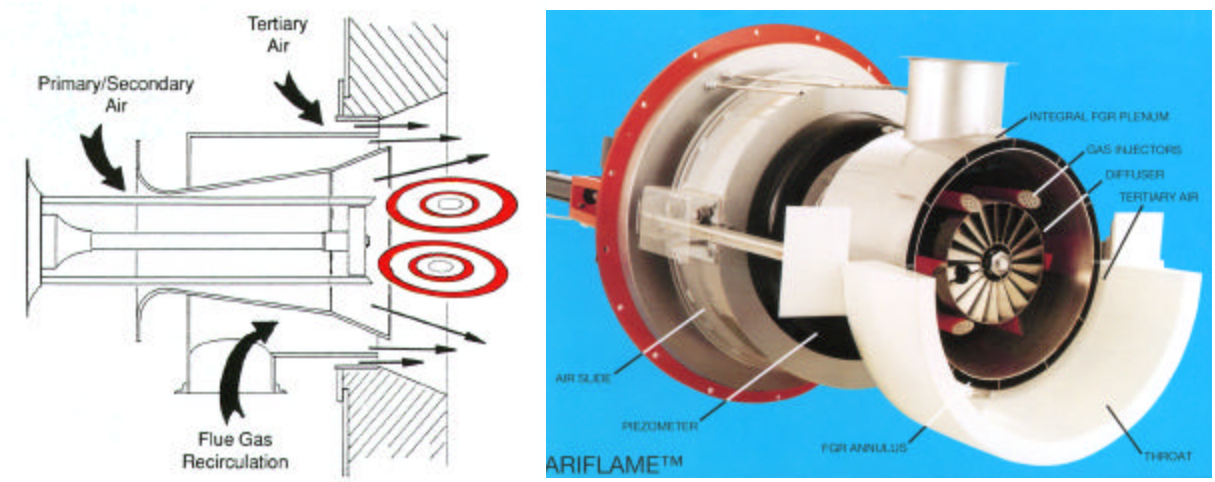

Figure App 2-4 Low-NO_x Oil/Gas Burner (Courtesy of Todd Combustion Ltd.)

The numerous designs of low-NO_x burners vary greatly in the shape of flame they produce, and therefore need to be matched carefully to the furnace in which they operate. Generally the flame envelope is larger than that of conventional burners, so flame impingement must be considered. Some burners have a long, narrow flame suitable for a most package boilers, but not for a short furnace. Further considerations are flame stability under changing load conditions, and for small, cold furnaces, the possibility of increased emissions of CO and hydrocarbons.

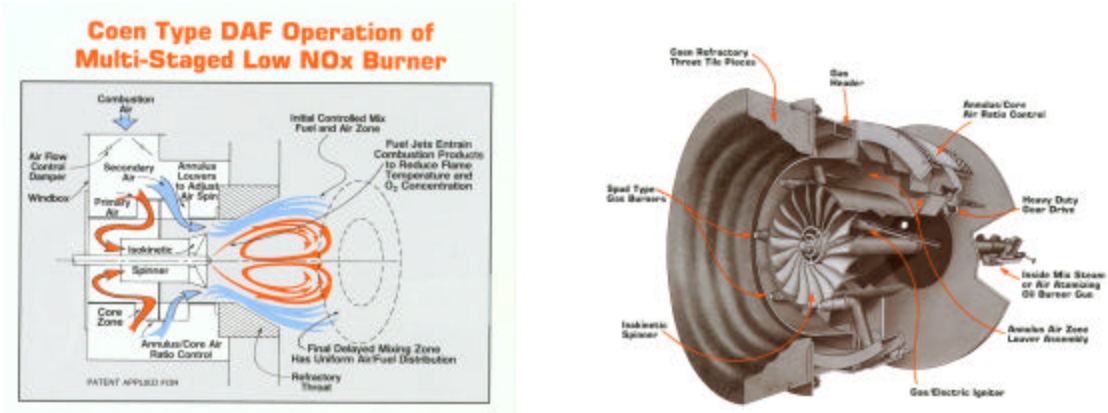

Figure App 2-5 Low-NO_x Oil/Gas Burner (Courtesy of Coen Company Inc.)